Chapter 18
Heating, Ventilating, and Air Conditioning System

18-1. General

Powerhouse heating, ventilating, and air conditioning are required to maintain temperature and air quality conditions suitable for operating equipment, plant personnel, and visitors. Maintaining required conditions for operating equipment is essential under all weather conditions at the site. Personnel and visitor design conditions are also important, but temporary deviations under weather extremes can be tolerated and should be reflected in the design. Energy conservation is a prime consideration. Figures B-21 and B-22 present typical heating, cooling, and ventilation systems. Drawings and specifications on a variety of systems in existing plants are available through inquiry to review offices. Adaptations of existing designs to new plants should consider the increased emphasis on energy conservation. The use of Class I ozone depleting chemicals (ODC) including all chlorofluorocarbon compounds (CFC), Halons, and their mixtures are prohibited.

18-2. Design Conditions

a. General. Assumed design conditions, both outside and inside the powerhouse, have major effects on system adequacy, construction costs, and operating costs since they influence the type of equipment provided. Sufficient engineering time for research and coordination of available data is essential to a practical design.

b. External conditions.

(1) Weather.

(a) Data sources. Sources of weather data include the following: American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) "Handbook-Fundamentals," TM 5-785, U.S. National Weather Service, power plants in the area, and miscellaneous private and public records. The ASHRAE Handbook is a reliable source for the locations listed therein, but power plant locations will frequently be some distance away from a listed location, and design conditions can be appreciably different in 50 miles (80.6 km) or less. In such cases, the designer should research other available data for applicability and authenticity. When other reliable data are unavailable, the interpolation procedure outlined in the ASHRAE Handbook should be used.

(b) Data required. Weather data and design conditions as listed in the ASHRAE Handbook are preferred and should be included in the mechanical design memorandum. Duration of hot and cold extreme temperatures is not usually included but is valuable when available to permit the design to reflect the "flywheel" effect of the normal massive construction of powerhouses. Outdoor design temperatures for comfort heating and comfort cooling should be based upon the 97.5 and the 2.5 percent dry bulb and corresponding mean coincident wet bulb temperatures, respectively. Outdoor design temperature for heating to prevent freezing conditions should be based upon the 99 percent dry bulb temperature.

(c) Evaluation. Data other than ASHRAE should be evaluated on the basis of location of readings, periods of record, probable dependability, and cross-checking to arrive at appropriate outside design conditions. The data should be combined and presented as nearly as practicable in the form noted in ASHRAE. Mechanical design memoranda should include the evaluation factors along with basic data and the assumed design conditions.

(2) Water temperatures. Streamflow temperatures will usually be available from the general design memorandum or other previous memoranda. Groundwater use is seldom economical for heating and cooling purposes, but temperature conditions are usually available through the U.S. Geological Survey offices. Probable pool water temperatures should be available in the Environmental Impact Statement, General Design Memorandum, or generator cooling water studies. Summer and winter water temperatures should be included in the design conditions data along with the data source.

(3) Ground and rock temperatures. General information on ground and rock temperatures is available in the ASHRAE Handbook. Because of the limited effect on system design, extensive research is usually not warranted. The design memorandum should include the ground and rock design temperature and the source or basis of assumption.

c. Indoor conditions.

(1) General. Indoor design conditions are on the following bases: project personnel requirements, taking into account the type of activity, visitor requirements, and equipment requirements. Personnel and visitor requirements are somewhat flexible allowing deviations during extreme outside conditions. Equipment maximum and

minimum conditions are more critical as deviations could affect plant capability or subject equipment to damage.

(2) Temperature-humidity. Indoor design temperature will vary with many factors, such as occupancy of the powerhouse, type of equipment, and sponsor/owner requirements. The control room office and visitor type of rooms should be heated and cooled to 20°C (68°F) and 24°C (75°F), respectively. Rooms with equipment which is sensitive to freezing conditions should be heated to a minimum of 4.5°C (40°F). Maximum humidity conditions should generally be limited to 50 percent in the office, control room, and visitor area. Minimum humidity control will seldom be justified.

(3) Ventilation. Ventilation rates should be in accordance with ASHRAE 62. Equipment/gallery rooms, battery rooms, and turbine pits generally should have minimum air exchange rates of 1, 2, and 4 air change per hour, respectively.

18-3. Design

a. General. The system design should be based on criteria, factors, and details recommended or indicated in the ASHRAE Handbook except as modified herein. The design should be conservative while providing acceptable operation with normal decreases in operating efficiency and average maintenance. Unnecessary complications to achieve ideal conditions under all operating extremes should be avoided. Heat gains from lights and equipment should be included in both heating and cooling load requirements with due reward for both initial and long-range plant operations.

b. Insulation. Powerhouse insulation is not normally a direct mechanical design responsibility. However, because of its influence on the required heating and cooling provisions and energy requirements, the mechanical designers should be involved in the initial powerhouse planning affecting insulation provisions. The most practical applications for insulated construction are usually the powerhouse walls above the bridge crane rails and roof. The "U" factors in the 0.05-0.09 range are practical for these surfaces. The use of windows should be minimized, and double-pane windows used where justified.

c. Heating.

(1) General. With the required emphasis on energy conservation, studies on the heat source and type of conversion equipment merit major design attention. Several options are open in most cases, and the factors pertinent to the selection should be included in the design studies and the design memorandum. System layout, equipment, and details in accordance with ASHRAE Handbook and reflecting previous powerhouse experience are normally satisfactory.

(2) Heat sources.

(a) Generator cooling water. The waste heat available in generator cooling water should be the prime source in all powerhouses where planned unit operation provides a reliable supply, or where practical modifications in unit scheduling could assure a reliable supply. Any plant with three or more units on baseload operation should have the capability for a continuous supply. Plants with planned intermittent or basic peaking operations may also provide a practical source if agreement on the necessary modifications in unit scheduling can be obtained. One or two unit plants located in areas subject to extended periods of subfreezing temperatures should not be dependent on generator cooling water as the basic heat source because of the limited backup capability. Preferred source water temperature in the 16°-24°C (60°-75°F) range can be obtained with reasonable modulation; however, the generator specifications should include a stipulation to this effect.

(b) Solar heat. Solar heat should be investigated for the powerhouse and visitor facilities. Solar heating studies should be based on the Department of Defense (DOD) criteria which are current at the time the powerhouse is being designed.

(c) Outside air. Outside air, using air-to-air or air-to-water heat pumps, has limited potential as the basic heat source because of reduced efficiency during subfreezing conditions. A study may be warranted for plants without a dependable water heat source, located in moderate climates.

(d) Pool water. Pool water may be a practical heat source where winter water temperatures above 7°C (45°F) can be assured. Caution in accepting pool water temperature estimates near 7°C (45°F) is advisable as the margin for safe operation is limited, and there are many variables affecting pool water temperatures. The existence of a similar project nearby on the same stream could provide a reliable indication of expected pool water temperatures.

(e) Miscellaneous water sources. Groundwater from wells or foundation relief flows can provide water of desirable temperature, but assurance of continued supply is questionable and these sources are not normally recommended.

(f) Electricity. Electricity utilized in resistance heating is an available and reliable source at most power plants. In many plants, it may be the most economical. Its disadvantage is the relatively low efficiency in the overall energy supply. Its use in resistance heating as the basic heat source should be limited to plants which meet the following scenarios:

- Where a reliable more efficient heat source is not available.
- Where total annual costs of an alternate more efficient source would exceed the cost of resistance heating by more than 25 percent.
- Where the total yearly heating energy demand is under 100,000 kW hours per year. Electrical energy used in resisting heating may be employed as required for auxiliary heat in occupied areas and temporary heat for maintenance and repair purposes.

(g) Oil-gas. These sources may be practical in some areas. The use of oil or gas is preferred over electrical resistance heating where a reliable source is available.

(3) Conversion equipment. Equipment to be considered for heating is water-to-air coil-type heat exchangers, heat pumps, and resistance heating coils. Heat pump capacity should be sized, or backup resistance heating provided, to assure capacity for maintaining above freezing temperatures within the powerhouse under minimum outdoor temperature with one compressor inoperable.

(4) Source water piping. Source water taps and headers should assure required water to the coils or heat pumps at all times. Generator cooling water should be supplied through a header connecting to a minimum of three units but may be justified to all units depending on plant size, proposed plant operation, and weather conditions. Pool water should not be subject to interruption from main unit shutdown involving placement of stoplogs or closure of gates. Strainers in the source water supply should be duplex, with strainer perforations as large as practicable and consistent with heat exchanger requirements.

(5) Heat distribution. The bulk of the powerhouse heat requirements will be distributed through the ventilation system with water-to-air coils. Resistance elements located in air-handling units or ducts should not be used unless resistant heat is the only practical method of heating the powerhouse. Heat distribution requirements may determine air quantities in the ventilation system.

d. Cooling.

(1) General. Cooling should be provided to meet the design conditions noted in paragraph 18-2. Wherever practicable, cooling should be provided by circulation of outside air through the ventilation system or by circulation of pool or tailwater through water-to-air coil-type heat exchangers in the ventilation system depending on which method is most economical. Where suitable outside air or water temperatures are not obtainable, cooling may be provided with chilled water coils in the ventilation system or package-type air conditioning units.

(2) Cooling load.

(a) Outdoor. Outdoor design temperatures should be based on ASHRAE summer design conditions as noted in paragraph 18-2. Allowance for sun exposure is particularly important for exposed gallery structures containing power cables or busses and heat sensitive equipment.

(b) Indoor. Indoor heat gains are essentially electrical and should be based on equipment manufacturers' data or connected load with conservative efficiencies. It is essential that adequacy of the cooling provisions not be a limiting factor in equipment or electrical conductor operation. It is also important that heat gain estimates for critical areas such as galleries with concentrations of electrical load be verified. Design memoranda should recognize such areas, show source or basis of heat gain estimates, and include appropriate factors for contingencies. In plants provided with indoor emergency diesel generators sets, the heat gains therefrom may be of significance and should not be overlooked.

(3) System and equipment.

(a) General. The bulk of the cooling requirements will normally be provided through the ventilation system either with outside air or water-to-air coils located in the air handling units or ducts. Auxiliary or isolated zone cooling using package-type air handling units or package-type air conditioners may sometimes be most practical. Cooling requirements will frequently determine maximum ventilation rates.

(b) Heat pumps. The joint use of heat pumps for heating and cooling requirements is the preferred method of heating and cooling if direct cooling from outside air or water is not practical.

(c) Compressors. Where cooling by mechanical refrigeration is justified, the compressor capacity should be provided with two or more compressors rated to provide approximately two thirds of system requirements with any one compressor out of service.

(d) Humidity control. Dehumidification will normally be accomplished, as required, in the system cooling coils. This may be a factor in determining required cooling water temperature.

(e) Direct expansion coils. Direct expansion coils in the main air system should be avoided. Chilled water coils are preferred. Direct expansion coils may be used where self-contained package-type air conditioners are justified.

(f) Precooling coils. A combination of precooling coils using pool or tailwater and chilled water coils may be used to conserve energy where economically justified.

(g) Package-type air conditioners. Simplification of the main powerhouse system and overall increased flexibility may frequently favor the use of package-type air conditioners with coil, blower, and filter for areas requiring special temperature control. This should be considered in the early design stage to assure space for appropriate locations. Required ventilation and exhaust air and chilled or heated water are normally provided from the central system when package-type air conditioners are used. Locations should provide for convenient access for servicing. Completely self-contained units with direct expansion coils, electric heaters, fans, and filters may occasionally be justified for small areas remote from the central system.

e. Air filters.

(1) General. Filters should be provided in all ventilation systems to reduce powerhouse cleaning and maintenance costs, aid in maintaining coil efficiencies, and improve air quality for personnel.

(2) Type. Several types of filters are satisfactory, including the following: electronic precipitator in combination with automatic roll type, throw away type, replaceable dry media type, traveling screen oil bath type, and automatic replacing roll type. Electronic precipitators are the most efficient in removing both coarse and fine foreign material from the air but will range up to double in annual costs over the other types. The other types have similar performance characteristics but differ in maintenance requirements. Normally, the choice of filter should be from the nonelectronic type with the selection made on the basis of lowest annual cost. Electronic types may sometimes be justified on the basis of unusually clean air requirements for certain equipment or to obtain better air quality for personnel in areas subject to unusually severe pollen conditions.

(3) Location. Filters are normally installed in air handling units, ahead of the coils, and in a position to filter both recirculating and outside air.

f. Ventilation.

(1) General. Ventilation is required as a minimum to assure reasonable air quality conditions throughout the powerhouse. Recirculation normally provides the principal ventilation air with the balance provided from outside air. The minimum outside air is based on the system requirements for rooms requiring outside exhaust, for direct use of compressors and gas or diesel engines, plus an allowance to assure a positive pressure within the powerhouse. Actual ventilation system air-handling capability will usually be determined by heating or cooling requirements. Provisions for heating, cooling, filtering, and humidity control are included in the system as required.

(2) Equipment. The principal supply and recirculating fans are normally installed in or adjoining air handling units containing heating and cooling coils and filters. Auxiliary heating or cooling coils, booster fans, and exhaust fans are located as required in the overall system. Automatic dampers are normally provided in generator room roof-exhaust ventilators to control the powerhouse positive pressure to approximately 2.54 mm (0.1 in.) of water.

(3) Miscellaneous considerations.

(a) Paint spray areas. Repair rooms or repair pits with paint spray equipment should be provided with supplemental ventilation for use during painting operations. The total ventilation provided should be at least 60 changes per hour. In addition, the installation should conform to the applicable provisions of NFPA 33 and 91.

(b) Emergency generator rooms. Rooms with gasoline or diesel engine-driven emergency generator sets should be provided with ventilation to remove heat given off by the generator, exciter, engine surfaces, exhaust piping, and heat exchanger, as well as with ventilation for engine combustion. Ventilation should be provided as stated in paragraph 18-2*c*(3) when the generator is not in use.

(c) Control room ceiling. Space above the control room ceiling should be provided with sufficient ventilation to remove the heat given off by the high-intensity control room lighting. Outlets and inlets should be arranged to provide uniform cooling and to avoid hot spots.

(d) Exhaust provisions. Toilet rooms, a battery room, oil storage rooms, paint storage rooms, control rooms, rooms with mechanical refrigeration, and similar spaces should be provided with exhaust to the outside during all seasons. Air from other spaces is usually recirculated when ventilation with outside air is not necessary for cooling. Automatic dampers and variable speed fans are generally used where two or more rates of ventilation are required. Provisions are sometimes made to discontinue or reduce the exhaust from public toilets and similar spaces during periods of peak heating loads in order to reduce the amount of makeup air required during the peak periods.

(e) Ducts. Ducts are usually constructed of galvanized sheet iron with suitable stiffeners. Vertical building chases and galleries are often used as ducts where economical. Galleries or corridors are often practicable for large volume air movements but should not be used where normal traffic in and out is heavy and door opening or closing would materially effect the operation of the ventilating system. Unbalanced pressure effect on door operation should also be considered, particularly where visitors may have access. Galleries with concentrations of heat-generating equipment may require metal ducts to permit concentrated delivery of cooling air or pickup of exhaust air. Use of louvered doors and corridors as a substitute for a return duct on an air conditioning system is unsatisfactory. Insulation for ducts should be provided where required to avoid condensation or where justified to conserve energy. All insulation should be of a fire resistant type.

g. Controls.

(1) General. Controls should be of the automatic type wherever feasible to minimize required manual adjustment and to discourage random “personal preference”-type adjustments. In summer-winter air conditioning systems, however, the master changeover should generally be manual to avoid unnecessary heating-cooling cycling during mild weather.

(2) Design. The general control system for each powerhouse should be developed along with the overall system layout to assure a well-coordinated design. Emphasis should be on minimizing energy usage and obtaining good average conditions in the powerhouse with minimum complexity and maximum dependability. In most powerhouse areas there is considerable latitude in acceptable conditions, which should be reflected in the control method as well as the system layout. In the interest of energy conservation, control requiring simultaneous cooling and heating should be avoided. Final control system design should be a contractor responsibility. Specifications should permit the contractor’s choice of pneumatic, electrical, or electronic control or a suitable combination.

18-4. Design Memorandum

The design memorandum should include the background information essential to selection of design conditions. The choice of methods of heating and cooling should be discussed and justified. Special conditions that warrant departure from the usual design criteria should be explained. Heat gains and losses should be tabulated by room or space and summarized by system. A flow diagram for each system should be furnished. Separate control diagrams for heating and cooling seasons are desirable on the air conditioning systems.